DREDGING THE DELAWARE

The activities of the District, however far-flung and complex, return to a theme which remains their perennial concern—the Delaware River. The river embodies most of the problems which are, for Philadelphia and the District area, both prime cause and end result. Annually the river generates total income of over two billion dollars for 100,000 area job holders; its ports rate second in the nation in total water-borne commerce. Its uncounted tributaries, including several sizable rivers, drain a basin of more than 12,765 square miles. Eventually, a part of almost everything finds its way down to the river; silt, sand, fertile topsoil, mine culm and waste from industrial and municipal outfalls.[1] Some of this material is carried free of the river by currents and tides to join the migrant spoil which shapes and reshapes the bottom of Delaware Bay; a large quantity of it settles to the river bottom and impedes the channels of navigation.

The development of a ship channel from Philadelphia to the sea began with the plan for permanent improvement of 1885; for many years prior to this dredging in the Delaware River had been performed only sporadically. Permanent improvement of the river now involves much more than the clearance of annual deposits of sediment from the ship channel; construction and maintenance of anchorages, dikes, revetments and harbors are standard operations; nearly standard are the periodic requirements for deepening and widening the channel to accommodate vessels of deeper draft.

The War in Europe in 1940 underscored the need for a deeper channel to facilitate the passage of capital ships to and from the

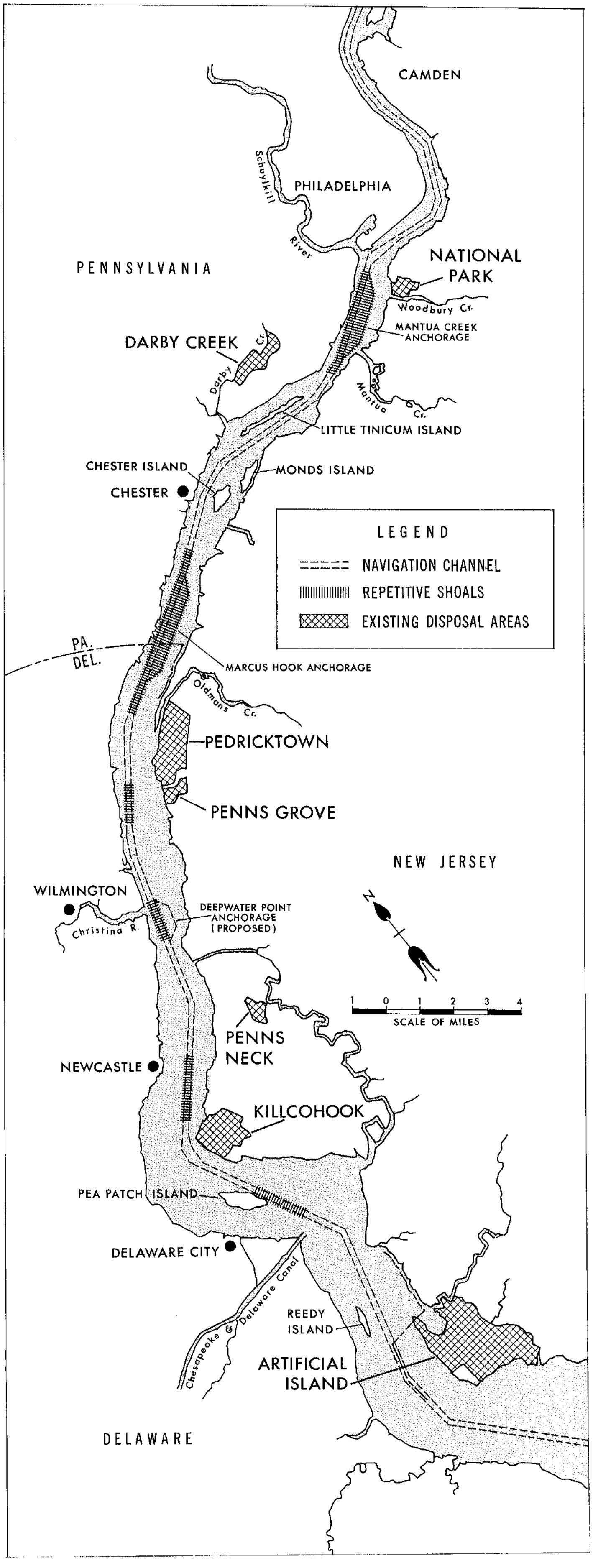


Chart adapted from the Long Range Spoil Disposal Study of 1969 showing the Delaware River between Philadelphia and Artificial Island. The bulk of the maintenance load of Delaware Channel dredging is concerned with the areas of repeated shoaling.

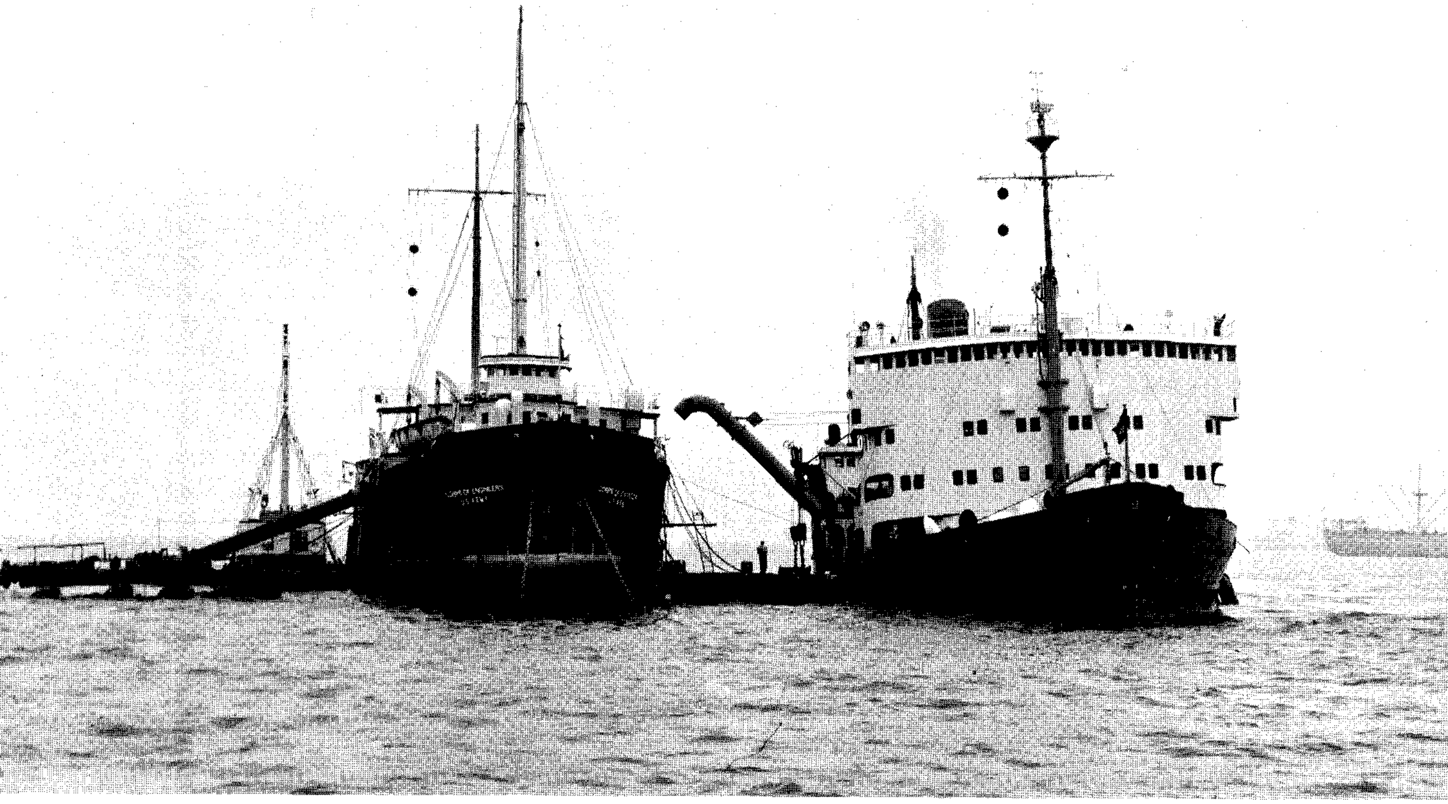
Philadelphia Navy Yard. A crash program was undertaken to deepen the existing channel to forty feet, from the Navy Yard to deep water in Delaware Bay. Dredging began 16 December 1940 and continued through 28 February 1942. The vessels assembled for the job included the U.S. hopper dredges *Atlantic*, *Chinook*, *Clatsop*, *Delaware*, *Goethals*, *Harding*, *Manhattan*, *Marshall*, *Navesink*, *New Orleans*, *Raritan* and *Rossell*, and the pipeline dredge *Gulf Port*. More than 42,048,005 cubic yards of material were removed from the river and deposited in rehandling basins or outside the channel limits at a cost of over four and a half million dollars. In addition, 2,378,852 cubic yards of material were removed by scouring by the hopper dredges *Chinook* and *Goethals*, and 499,833 cubic yards were removed by the pipeline dredge *Gulfport*.

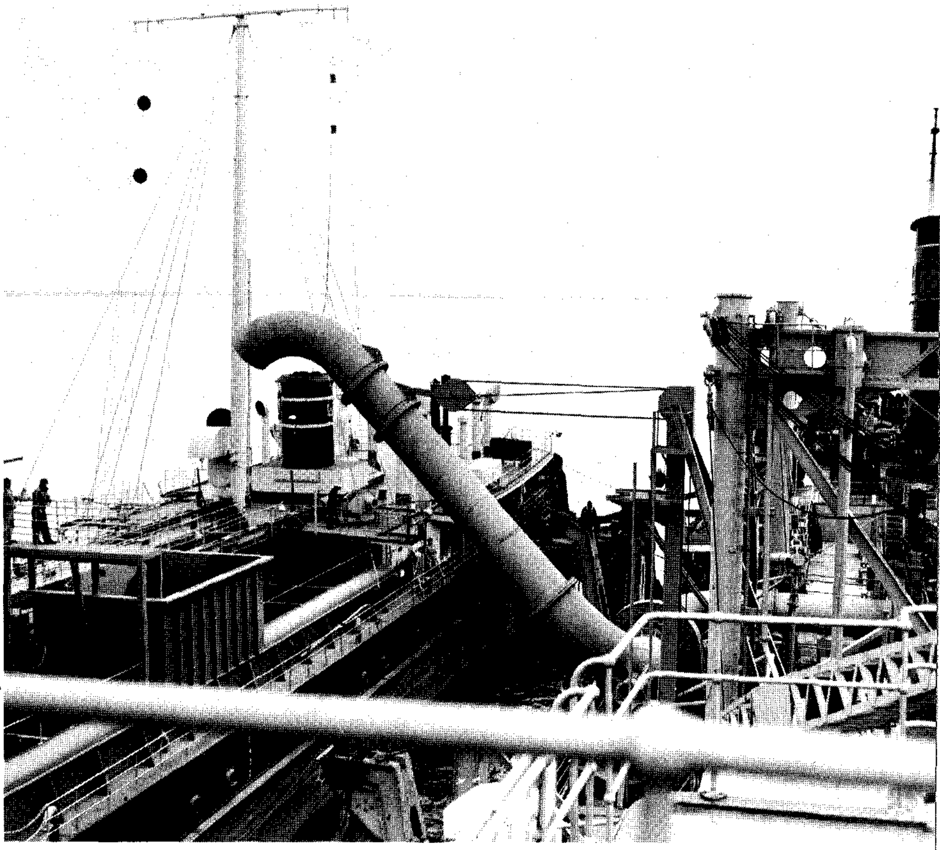
To maintain that channel, from July 1942 to June 1943, more than 29,000,000 cubic yards of additional material were dredged from the Delaware- a volume of mud which confined within the building lines of Philadelphia's Broad Street would form a wall 100 feet wide, 122 feet high, and 12 miles in length reaching from City Line on the north to the Philadelphia Navy Yard. Beyond that, 121,000 cubic yards of rock were drilled and blasted from the river bottom.

The river's behavior patterns have been graphed and charted throughout the years; logs of the tides and currents, surveys of the river bed and samples of collected sediment provide clues for defining the river's essential character. Model studies are regular planning features in all of the District's surveys for water-related projects. These are carried out at the Corps of Engineers' Waterways Experiment Station at Vicksburg, Mississippi. Today, the conformation and volume of recurrent shoals can be effectively predicted and the cost of their removal realistically estimated. The major assignment of the District's Operations Division is the physical care and management of the Delaware River and is handled by a staff of civil engineers and survey crews, working with maintenance depots and a sophisticated floating plant. The pride of the fleet are the District's three seagoing hopper dredges.

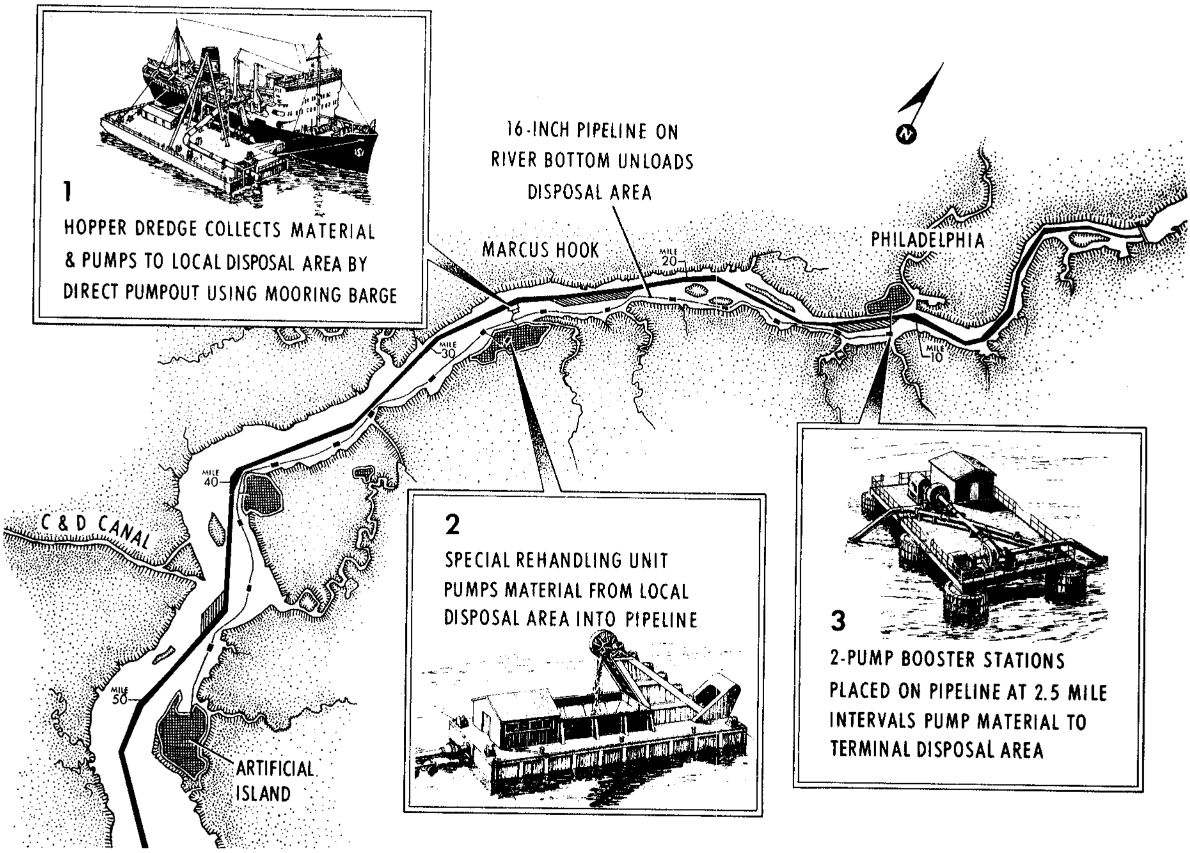
In order to keep abreast of the combined inflow of solids, it is necessary to remove about five million tons of material each year from the river. This material is drawn into the dredge hoppers, hauled to prepared locations and pumped ashore. All hopper dredges are equipped with dump valves in the bottoms of the hoppers; years ago these were used to dispose of all dredged material. Today, bottom dumping is practiced selectively, the preferred method being to place the material in dike-inclosed shore sites, exercising considerable precaution to prevent spillage into the stream. Planning the regimen of a spoil disposal area is, in itself, a demanding feat of engineering.

The state of the art is such that virtually any known material can now be removed from subaqueous sites. An array of versatile cutters, drills and dragheads, rigged to powerful engines and pumps, are there to implement the empirically well-established techniques. However, even under usual conditions, the planning and pricing of a maintenance dredging job is far from being a perfunctory exercise. While the usual condition, with all of





The Sump Rehandling System.
Converted hopper dredge New Orleans, the rehandler, (above, left) is about to receive and pump ashore the material from a dredging run of hopper dredge Comber.
Dredge Goethals' distribution pipe (right) is being lowered to the receiving bin of the rehandler.



A Dredging Scheme for Delaware River

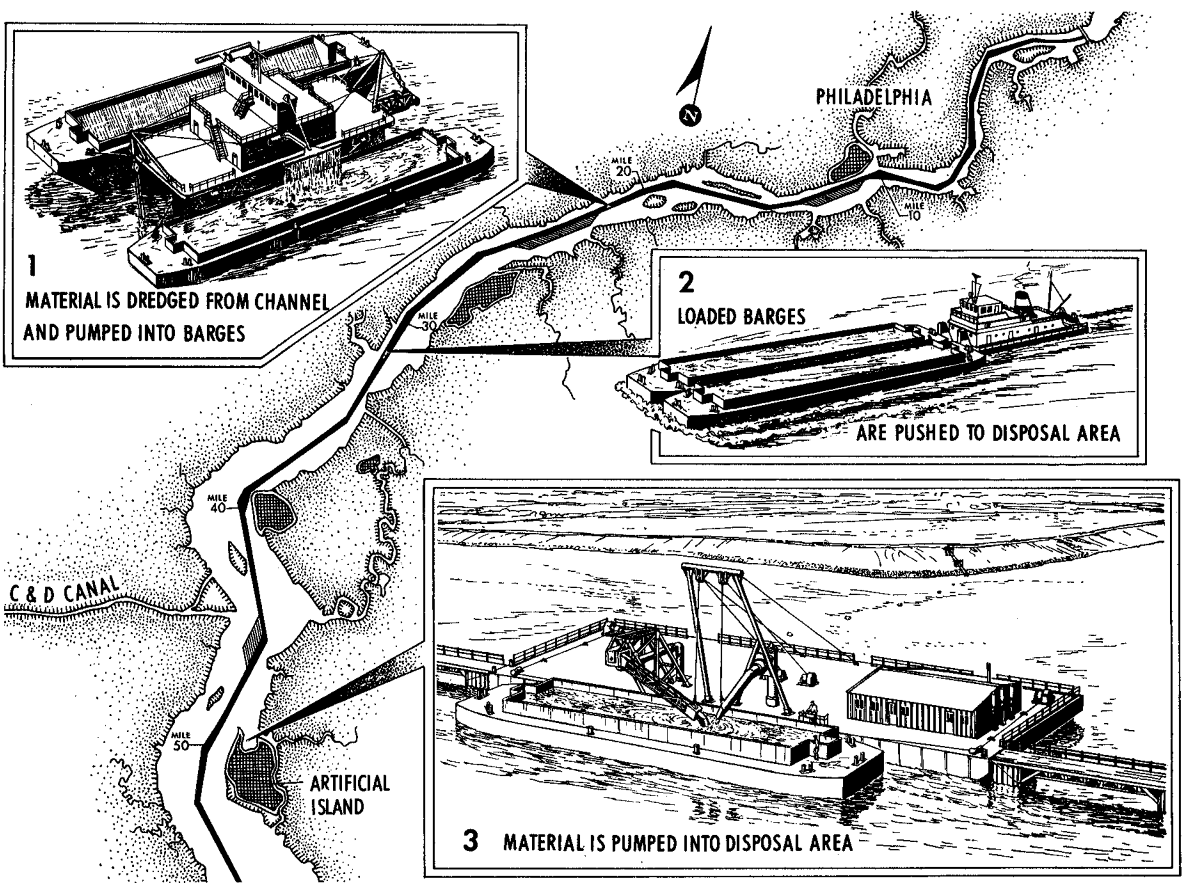
Pumping dredged spoil through pipelines 25 to 50 miles long is a feasible solution to the problem of unavailable upriver depositories. Using existing disposal areas as rehandling basins, the material is deposited in the usual manner after the hopper dredge has made a dredging run; an endless chain bucket dredge then delivers it to a 16-inch pipeline through which it is pumped to a final fill area.

Practical application of the system and its economic feasibility are contingent upon the availability of accessible, satisfactory fill sites.

its variables, is adequately resolved by the existing mechanical plant, the District's engineers maintain a forward view, seeking to anticipate the river's changing requirements.

Upland erosion will undoubtedly continue to contribute largely to the sedimentation of the Delaware River; proposed land management programs, to be activated by other agencies, may eventually reduce upstream sediment production, but doubtfully in amounts that in turn would significantly reduce the annual dredging load. Mine clum is a lesser problem than it was prior to the Schuylkill River Regeneration Project of 1945.[2] The Clean Streams Act of that year put teeth in the State's directives interdicting the discharge of industrial effluents into the Schuylkill River. There is little prospect of effectively reducing the work load of the District's dredging plant in the foreseeable future; on the contrary, an augmented program is anticipated due to constant pressures for enlargement of the navigation channel. The current project calls for a channel 40 feet deep with a width ranging from 400 feet in Philadelphia Harbor to 1,000 feet in Delaware Bay. Local maritime interests have requested that channel dimensions be increased to a depth of 50 feet and widths of 1,000 to 2,000 feet. Channel studies in progress in the District seek to determine the need for modification of channel and anchorage dimensions. District planners have met informally with representatives of the petroleum industry[3], who desire a 72-foot channel between the Atlantic Ocean and a proposed unloading terminal in Delaware Bay.

The disadvantages of an inland port have been clearly recognized in assessing Philadelphia's capacity to have commerce with an increasing number of supertankers and gigantic ore carriers. Most of the crude oil shipments arriving at Delaware River refineries originate at foreign deep water ports; 350,000-ton tankers with drafts of over 70-feet are already in operation. Similarly, the area's steel mills are nourished by ore from foreign sources. This trend to mammoth hulls necessitates serious consideration of available alternative methods to assure delivery of vital cargoes to Delaware River ports. The attributes of a deep water Terminal Facility in lower Delaware Bay[4] from which crude oil could be transshipped by barge or pipeline to up-river refineries, are receiving considerable attention in the oil industry. However Delaware River Channel depth in the 70-foot range is regarded by District engineers as unfeasible; any further modification of the channel, even to 45 or 50 feet, should be preceded by a thorough study of the subsurface materials. An access channel from the Atlantic Ocean to the proposed Deep Water Facility in Delaware Bay is deemed physically and economically practicable; natural depths in the project area range from 60 feet to well over 70 feet; material requiring removal for a 72-foot channel in the lower bay would amount to less than one-thirtieth of that required to provide a 50-foot channel to Philadelphia.



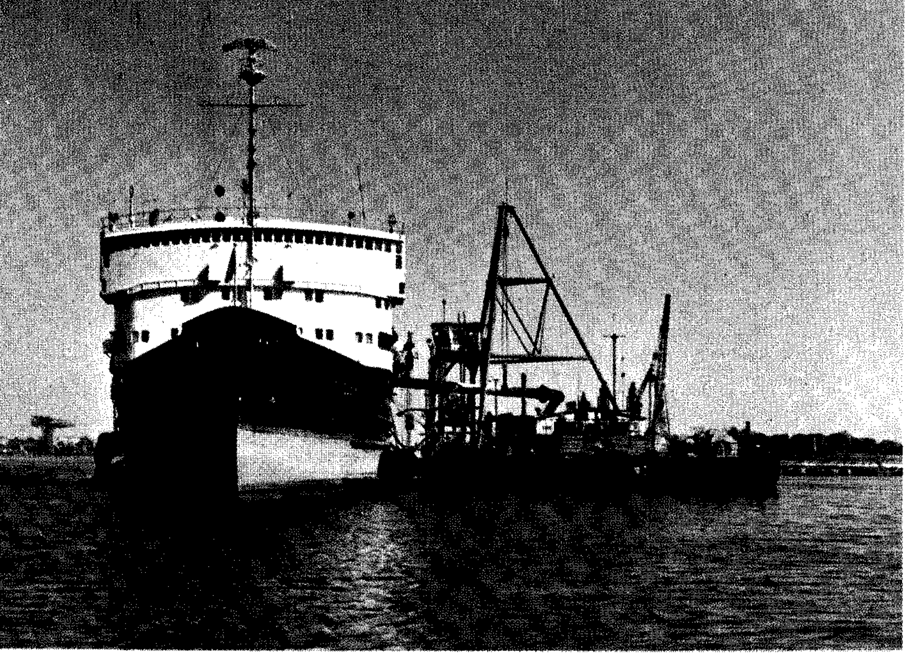
The proposed special dredge, shown in sketch No. 1 with barges alongside, is the core of this scheme for Delaware River channel maintenance.

There is, then, a large and potentially increasing requirement for annual removal and disposal of channel refuse from Delaware River. The rapidly changing river scene portends drastic revision of the traditional concepts of local channel dredging. Old disposal areas are filled or will soon be filled to capacity and the availability of new disposal areas becomes more restricted with each passing year. Riparian real estate is being absorbed in the general industrial-urban sprawl and land values are spiraling upward. Tidal marshes between Philadelphia and Trenton, once available as potential disposal areas, today are virtually nonexistent; many of the coastal marshlands below Wilmington are reserved for wildlife habitat. The situation in prospect is one of a continuing superabundance of material and a diminishing availability of disposal space.

An overall engineering study was undertaken by the District in response to a request by the Chief of Engineers to seek long-range solutions of Delaware River dredging problems. The Long Range Spoil Disposal Study, in seven parts, was prepared and issued under date of June 1969. Starting with the premise that removal of channel maintenance silt to shore locations could not proceed indefinitely, the six substudies investigated the causes of shoaling and the development of new dredging equipment and techniques; the merits of transporting spoil through extensive pipelines; river training works; anchorages and the alternatives to continued enlargement of the channel. Plate I of Appendix "G," Substudy 1 showed the relative locations of existing disposal areas and the recurring shoaling of the ship channel; the proximity of the two revealed a convenience and economy of operation not to be equaled after these disposal areas are filled to capacity.

Alternative solutions were proposed which assumed the continued availability of dumping sites farther down river, requiring longer lines of transport for the collected material. One scheme evolved a concept of pumping through a pipeline from a disposal area near the dredging run to a remote repository, using successive booster stations. The proposed system would utilize the existing plant, combined with new units of special design; shoaled material would be removed from the channel by hopper dredge and deposited in the rehandling basin by the direct pumpout method. The endless chain bucket rehandling method was selected for its simplicity and its capability of delivering the material in near-original density. Components of the projected pipeline and booster pump stations included standard industrial hardware.

A second concept focused on a proposed special Delaware River dredge, a self-propelled twin hulled craft with two centerline dragarms, one pointing fore, the other aft. Propellers at either end of the hulls would afford maximum mobility and avert the necessity of turning about at the end of each cut. Essentially a pumping plant, the stripped-down system provided no space for spoil storage; barges secured at either side would receive the material directly from distribution pipes as it was raised from the river bottom by the dredge pumps. Loaded barges were to be tugged to the distant disposal area and emptied by an unloading unit, consisting of a permanently moored barge equipped with a hydraulic hopper unloading facility.



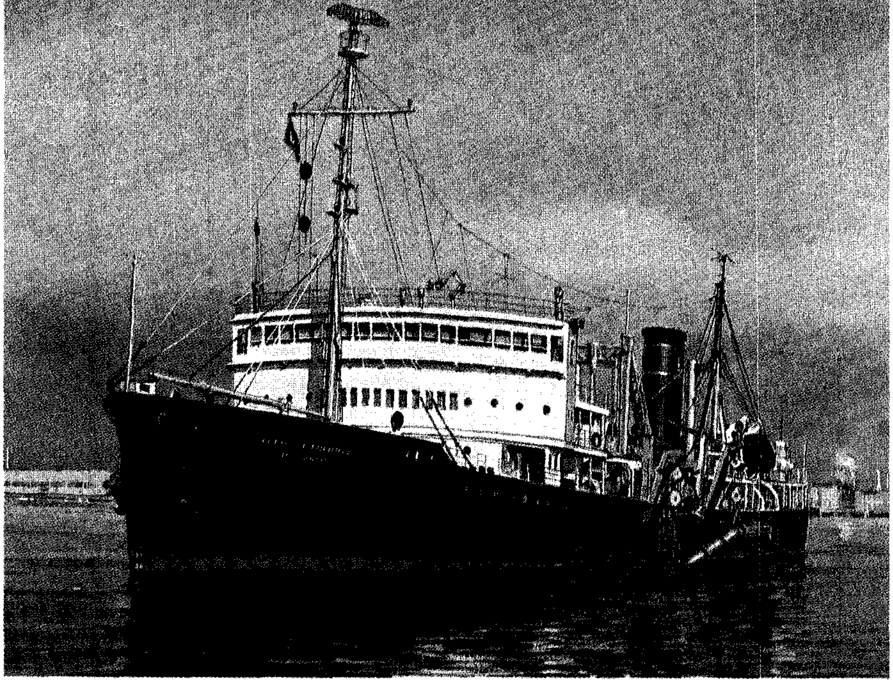
Direct Pumpout.
Dredge Comber, moored to Mooring Barge No. 1, uses her own pumps to deliver spoil directly ashore through a floating pipeline.

This scheme appears to be the most practically innovative yet formulated for the specific needs of Delaware River maintenance, since the Direct Pumpout system of dredging was inaugurated by the District in 1963. Each new system has been a forward step toward the goal of achieving positive retention and disposal of the particles of dredged material. Prior to 1954, material was bottom-dumped into rehandling basins, then pumped into near-by disposal areas; other material was free dumped in the estuary. Particles returned to the stream by this system amounted to a loss of 77 percent of the total dredged material. The Sump Rehandling system was put into operation in December 1954; concurrently, new, stringent practices were adopted which prohibited pumping into hoppers beyond overflow, the rehandling of dredged material in open waters and free dumping. The 42-year old hopper dredge New Orleans was converted to receive the loads of the dredging unit, store the mixture and then pump it ashore. It soon became obvious that the Sump Rehandling method reduced dredging effort by one half and produced a markedly improved channel.

The Direct Pumpout system become operative in March 1963, replacing the Sump Rehandler with a method of improved efficiency and greater economy. The Rehandler unit was supplanted by a simple receiving facility—a substantially-secured mooring barge devoid of pumps and spoil storage space. Its channel-depth anchorage permitted the hopper dredge to tie up alongside and couple with the barge's distribution pipe; the dredge pumps supplied all the power needed to deliver the spoil to a shore-based disposal area through a ponton-mounted pipeline. The improvement lay in the simplification of the system, the removal of a needless step and its corollary cost; little change was effected in the system's capacity to efficiently retain and store dredged fines.

Direct Pumpout is the maintenance dredging system currently operating in the Philadelphia District. Essential to the system is the disposal of spoil in confined, controlled areas. The adoption of new systems to implement new urgently-anticipated technique awaits only the definition of the new programs; but basic to any program is the problem of disposal area availability. The long view demands the appraisal of a host of hard questions; the needs of future commerce; effects of oil import restrictions on the economy; possible dangers of salinity intrusion; problems created by the increase in vessel size and draft; influence on both the marine life and the geology of the river bed are among the most urgent.

A new ingredient, which must leaven every projected formula for development, is con-



Hopper Dredge Goethals

sideration of the possible damage to the environment. The ecological repercussions of large scale dredging operations in the Delaware River are at this time imponderable. Although in-depth specific studies are not yet available, it is possible to speculate concerning extensive channel digging. An inevitable by-product would be enormous magnification of the spoil disposal dilemma. An acceleration of the rate of shoaling could be expected, if data for the Marcus Hook Range may be used as a precedent. In that area, where one-half the total Delaware River maintenance effort is expended, the shoaling rate has increased 700 percent since the enlargement of Marcus Hook Anchorage, the silt accumulation averaging one foot per month. The implications of a channel bottom at depths in of 70-75 feet include not only the added mechanical difficulty of materials removal, but more critically, the probable deleterious effects upon ground water supply sources in Delaware and Southern New Jersey. There is plausible concern that salt intrusion would increase in range and volume, to the detriment of estuarine marine life and Philadelphia's water supply. Moreover, dredging might seriously endanger the ecological cycles of the bay's bottom life, severely damaging the oystering and fishing industries of the region.

There can be no easy answers to the complex problems confronting those who work for the continued vigor of Philadelphia Port area. District planners and others pursue their endless search for effective and equitable ways of resolving these issues, while the dredges continue working around the clock to keep the Delaware channel clear.

Hopper Dredge Comber